1.3 Predator-fishery overlap and predator performance

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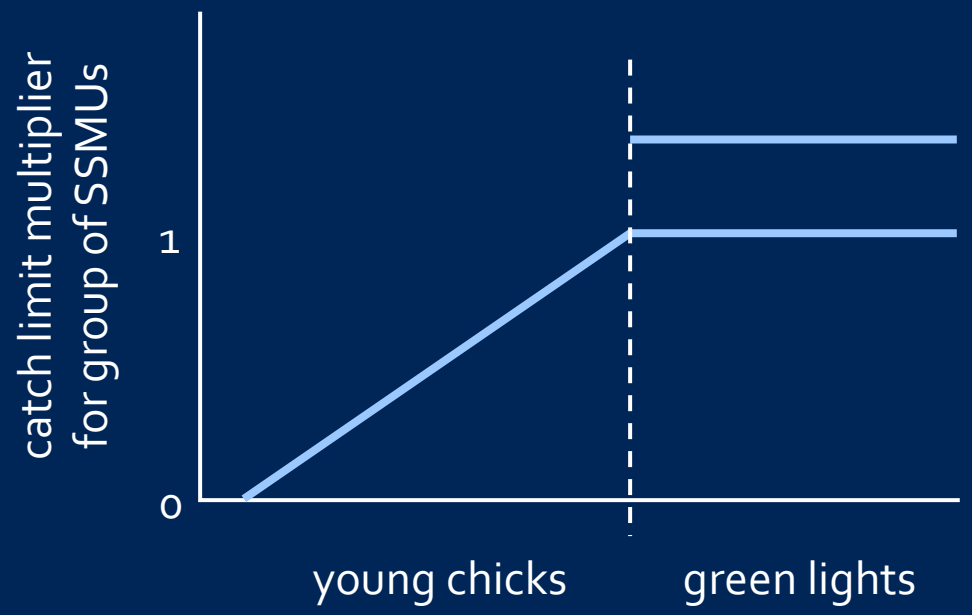
Southwest Fisheries Science Center
Antarctic Ecosystem Research Division

TOR QUESTIONS: 4, 5



1.6 Synthesis

1.5 Adjust up

1.4 Base catch limit

1.6 Adjust down

1.2 & 1.3 Background

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Why overlap of predators and the fishery?

- Estimation of functional responses of predators to changes in krill biomass has been elusive
  - Such data represent a more traditional approach to ecosystem based fisheries management

- Overlap demonstrates interactions on spatiotemporal scales relevant to predator performance and fisheries management
  - Indicates where risk could be greatest

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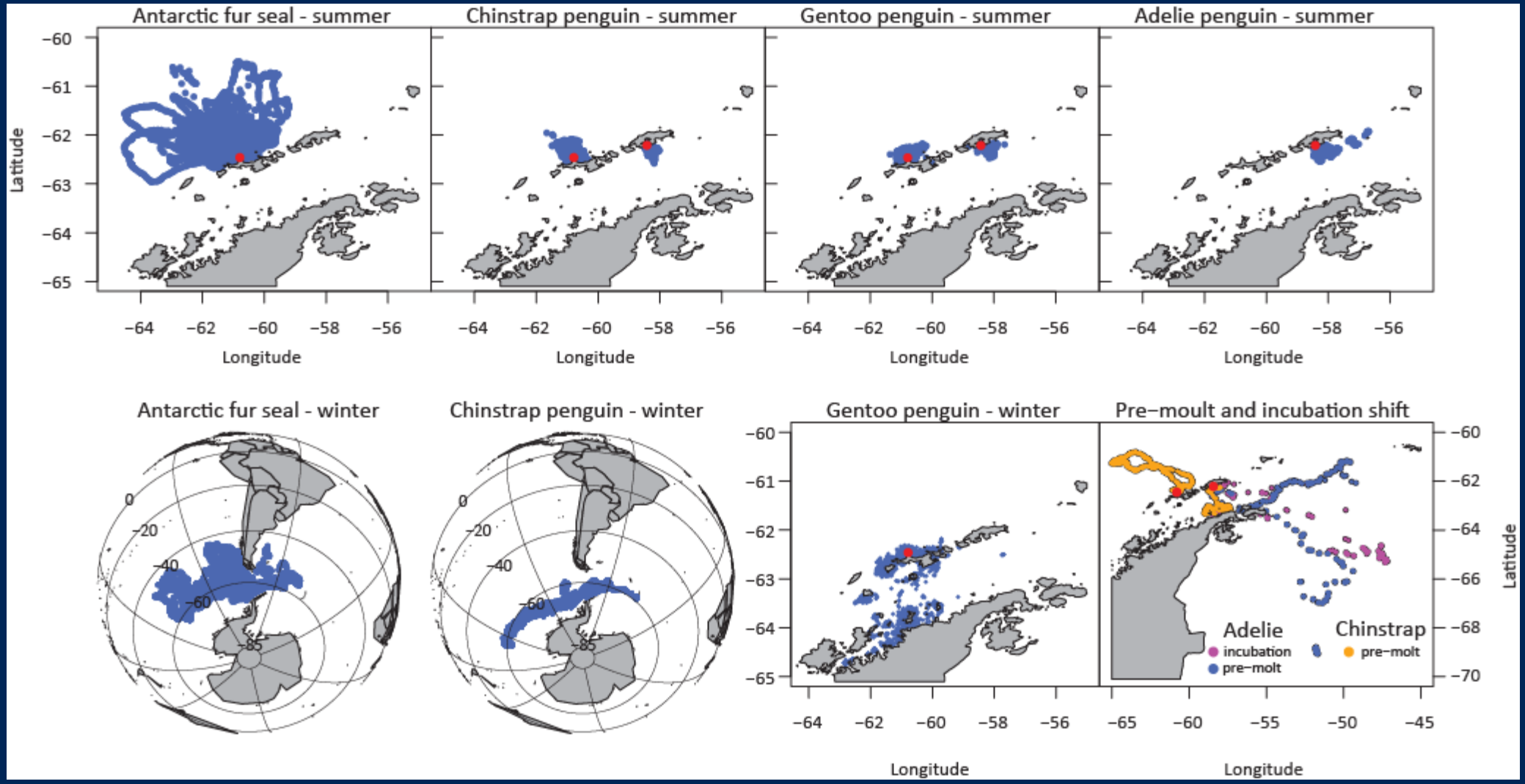
Predator location data, 2009-2014



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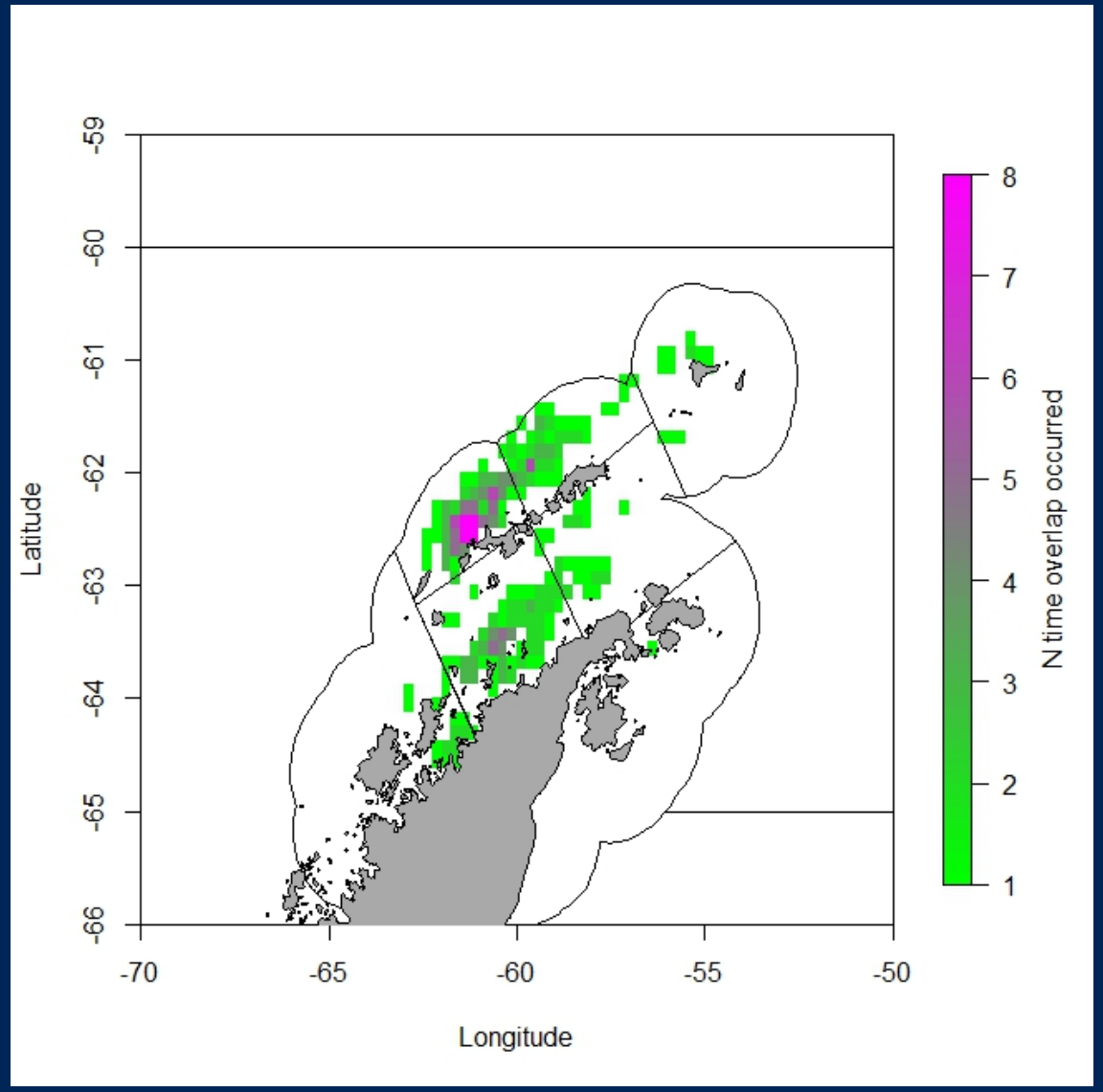
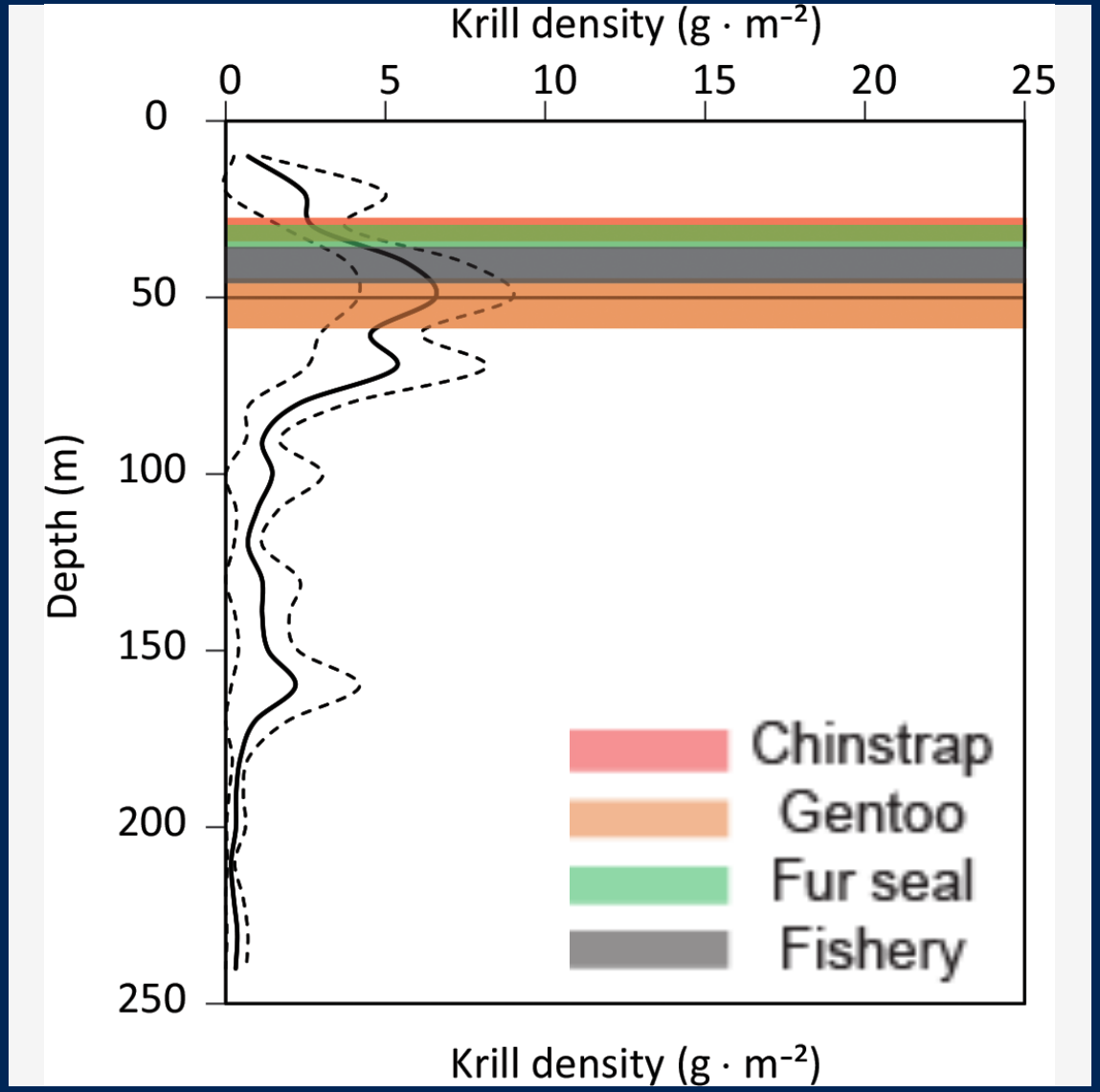
Overlap is extensive in space and in depth





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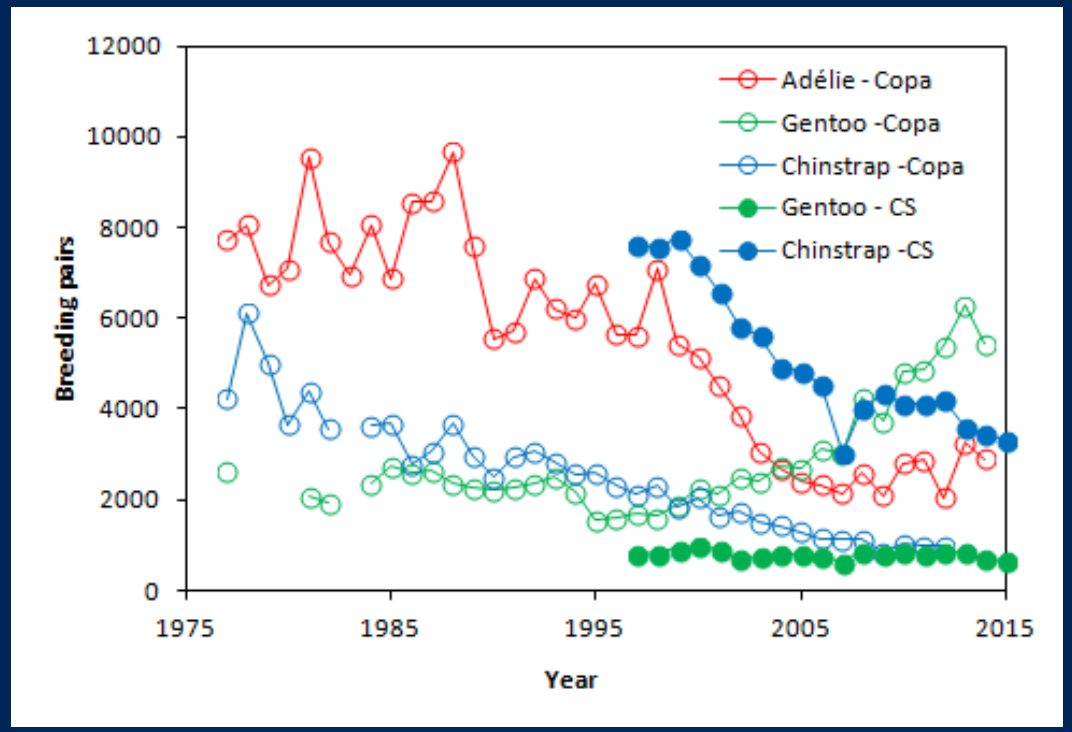
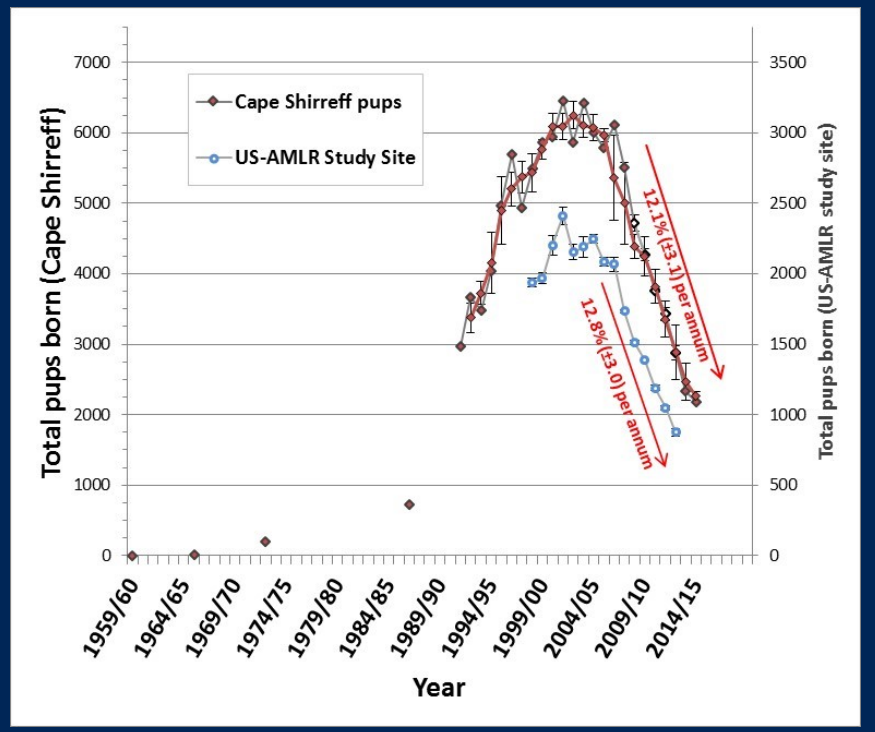
Predators in an ecosystem context: Environmental, bottom-up, and top-down drivers







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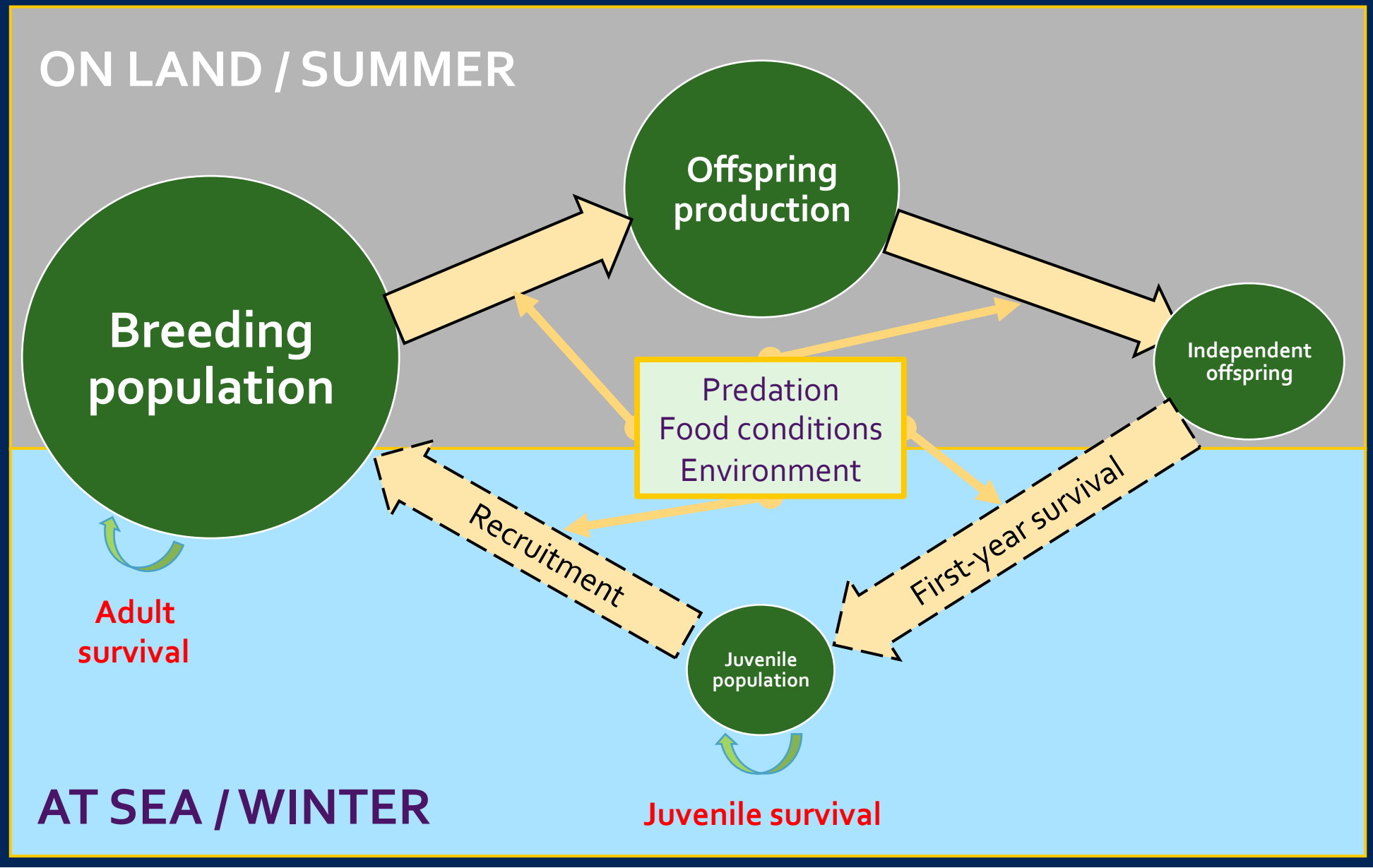
Generalized life cycle guides inference



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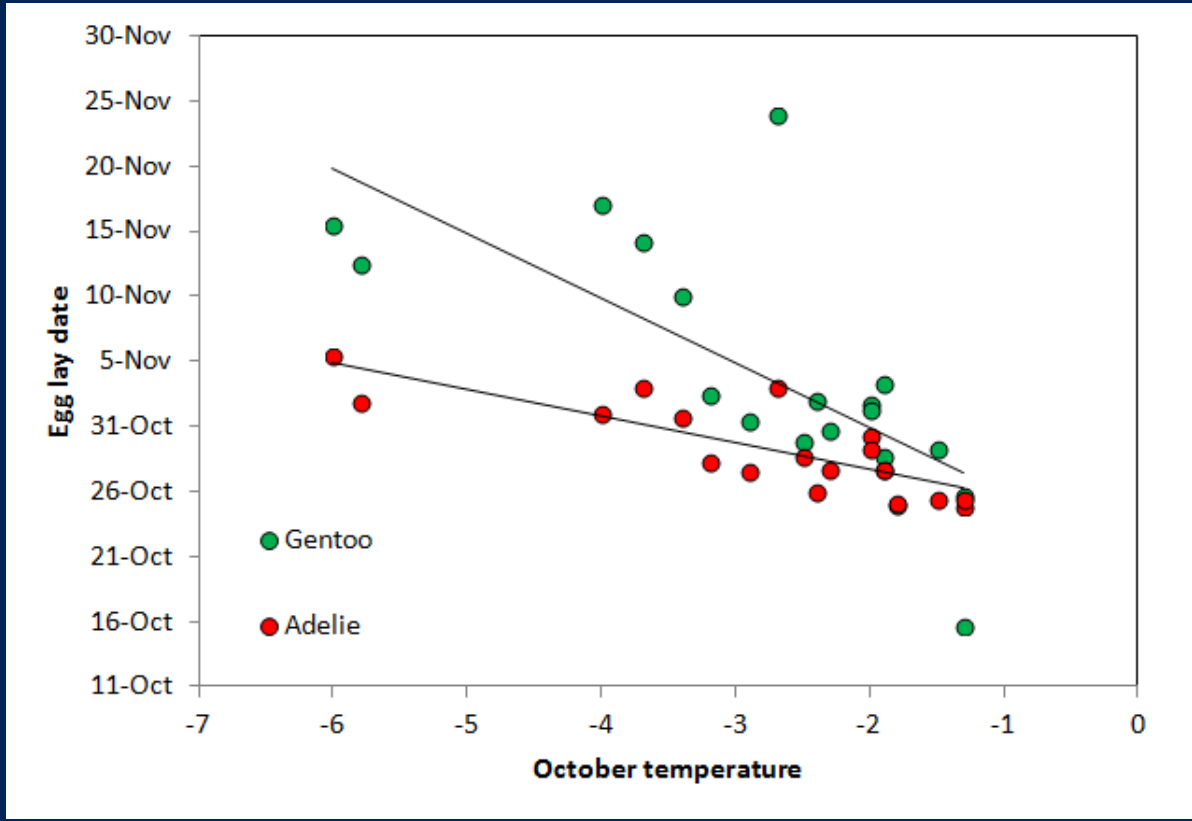
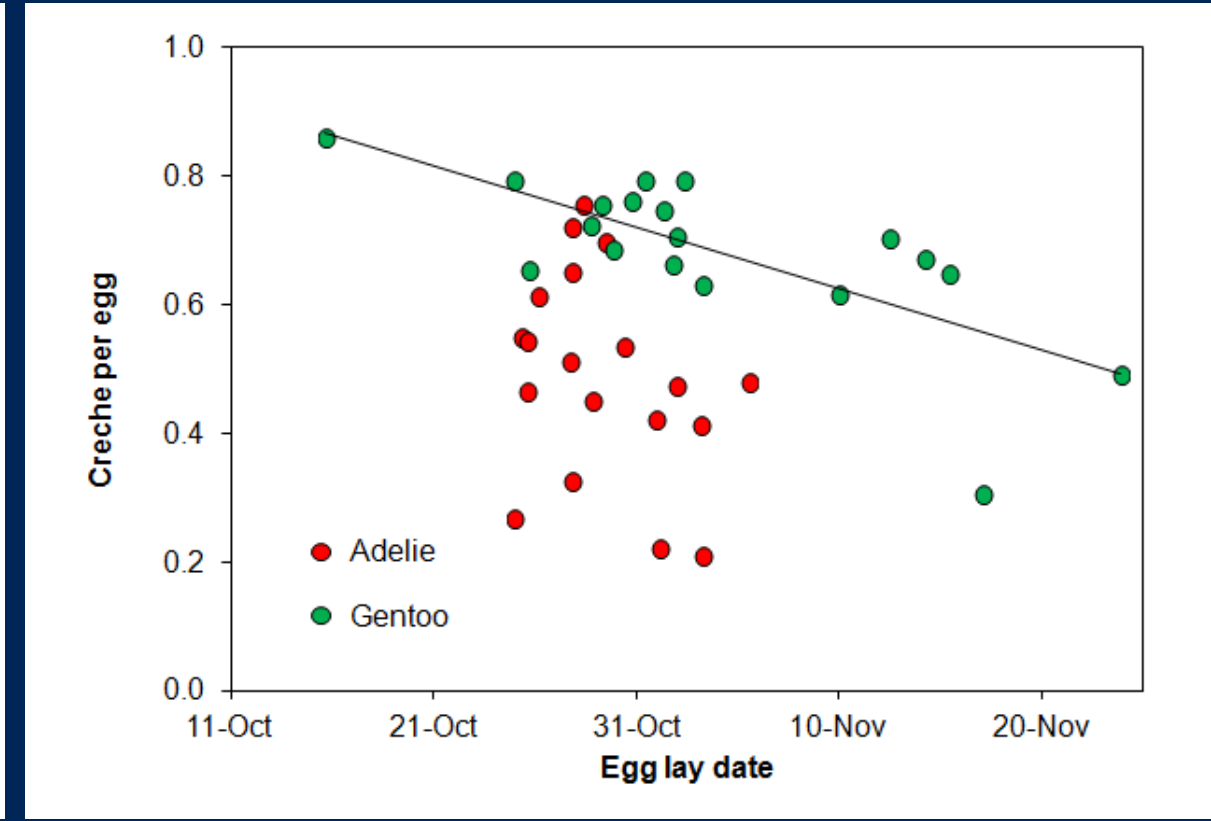
Environmental drivers are important





Phenology sensitive to temperature → Reproductive success sensitive to phenology

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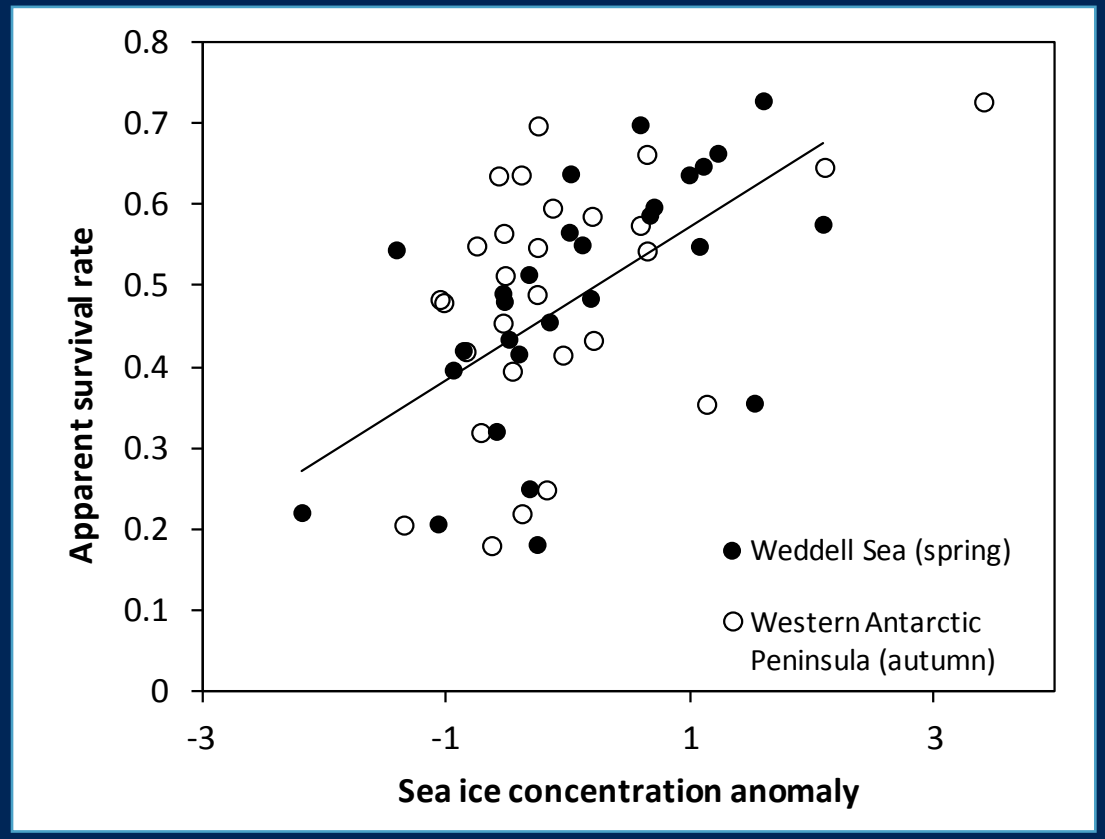
Hinke et al. 2012

Environmental drivers are important



Sea ice correlated with survival

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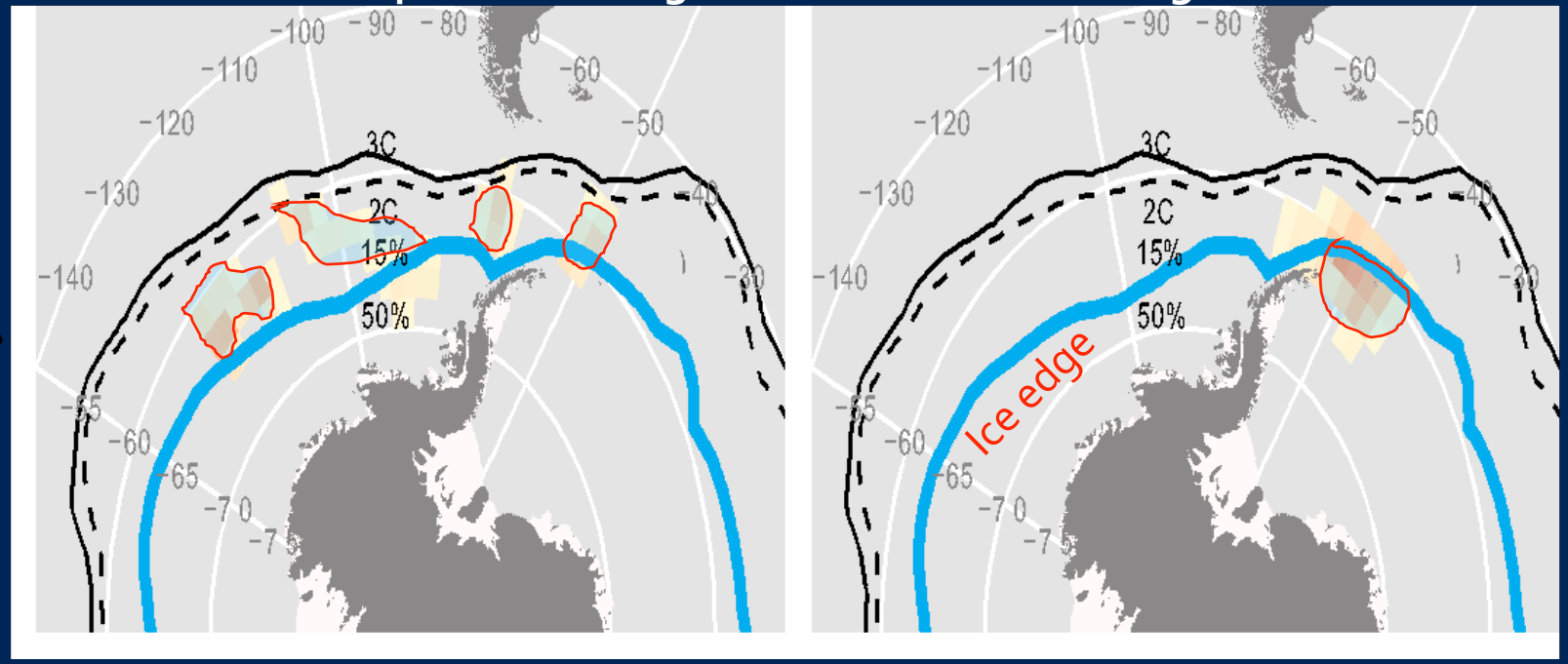
Hinke et al. 2014

Environmental drivers are important, but insufficient

Mid-winter distributions

Chinstrap: ice-avoiding **Adélie: ice-obligate**



The "sea-ice" hypothesis fails

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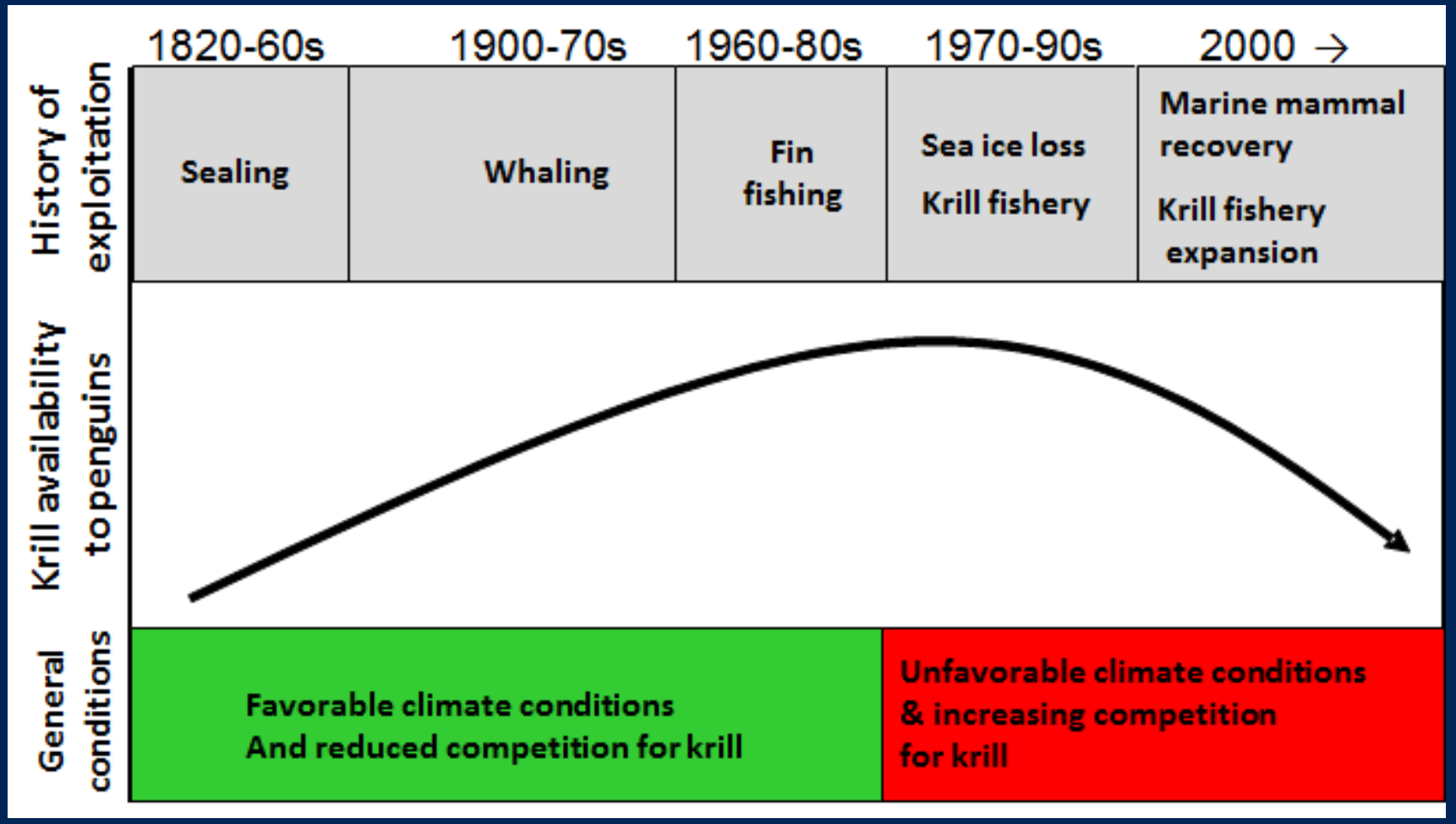
Hinke et al. 2015

Bottom-up:
Availability of primary prey is key



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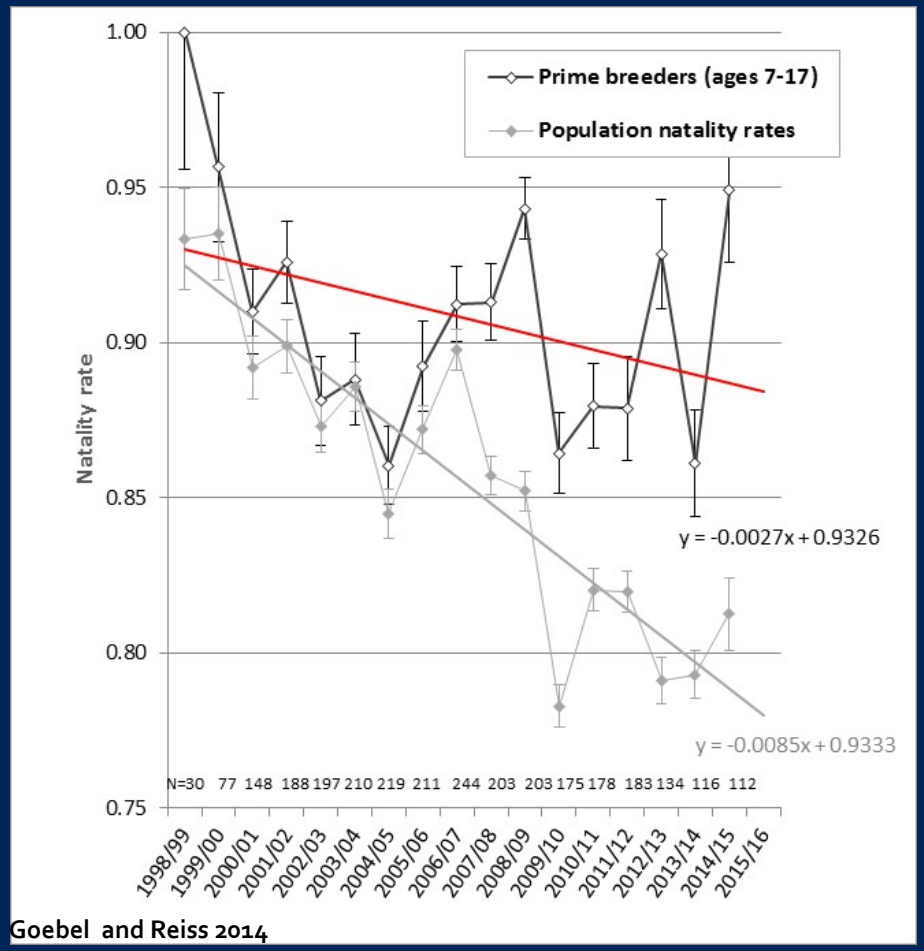
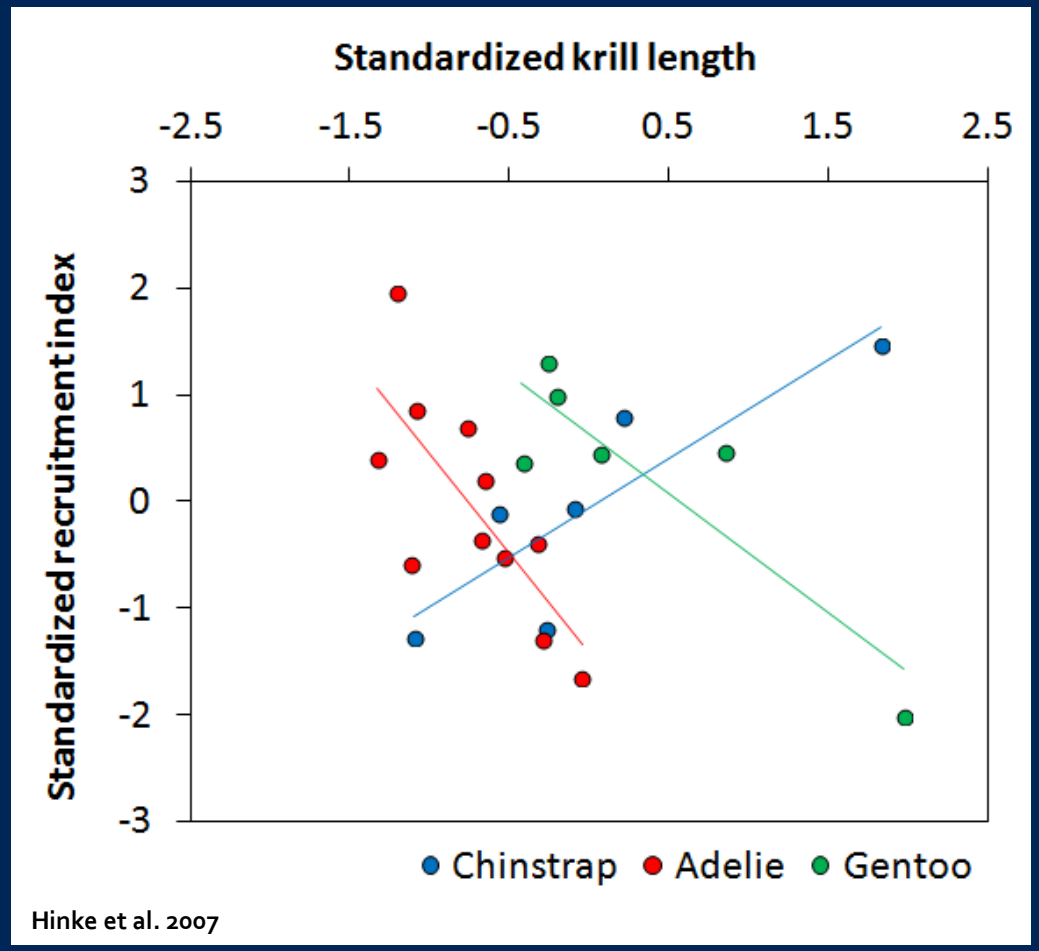
Trivelpiece et al. PNAS 2011

Bottom-up effects manifest in a variety of ways



Goebel and Reiss 2014

Natality rates in fur seals have declined



Hinke et al. 2007

Penguin recruitment correlated with krill sizes

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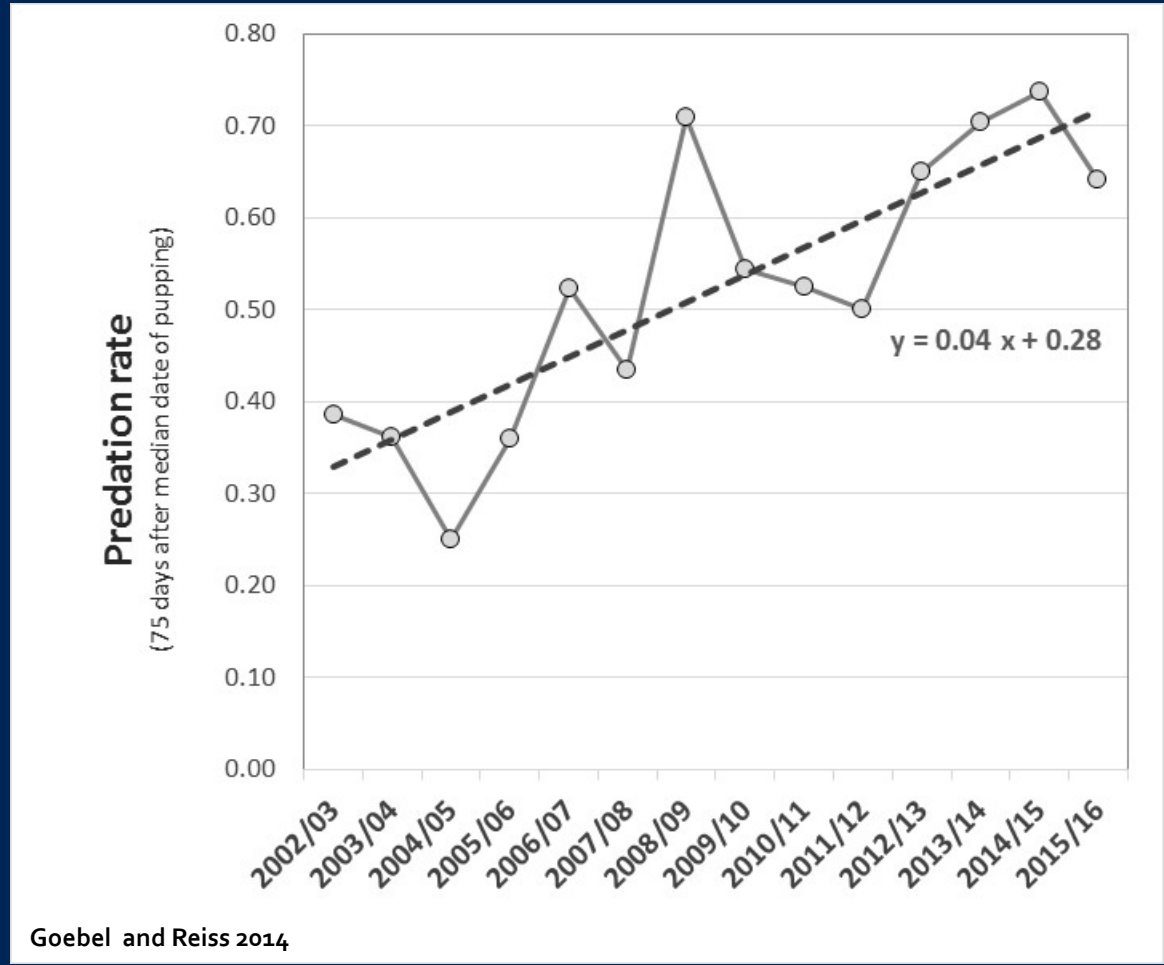
Top-down impacts also evident

- Anecdotally in penguins:
  - Observed complete loss of small colonies due to avian predation
  - Models describing population dynamics perform best with depensatory dynamics (Hinke et al. 2008, Watters et al. 2013)
  - Carcass accumulation on beaches at the end of the breeding season (leopard and fur seal predation)



Goebel and Reiss 2014

Fur seal pup loss due to leopard seals

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Meta-analysis: an integration of monitoring data

Does predator performance vary with changes in krill biomass or local harvest rates?

Data from 3 species at 2 sites

Winter responses:
- relative cohort strength
- male mass at lay
- female mass at lay
- lay date
- mean egg density

Summer responses:
- post-hatch success
- trip duration
- fledging mass

Spatially and temporally match predictors

winter biomass estimates
winter catches

summer biomass estimates
summer catches

Bayesian ANOVA based on "order of magnitude" estimates of krill catch and biomass

Compare standardized response values observed under different conditions of krill catch and biomass

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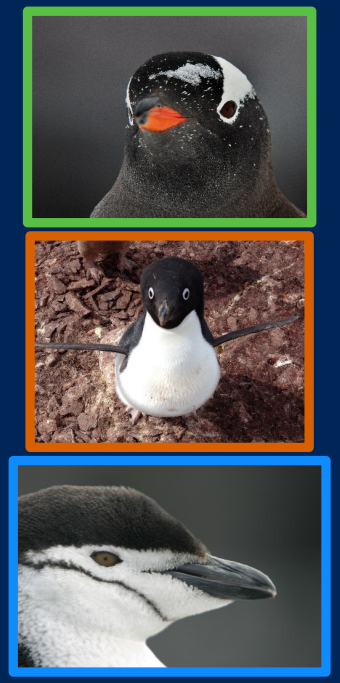
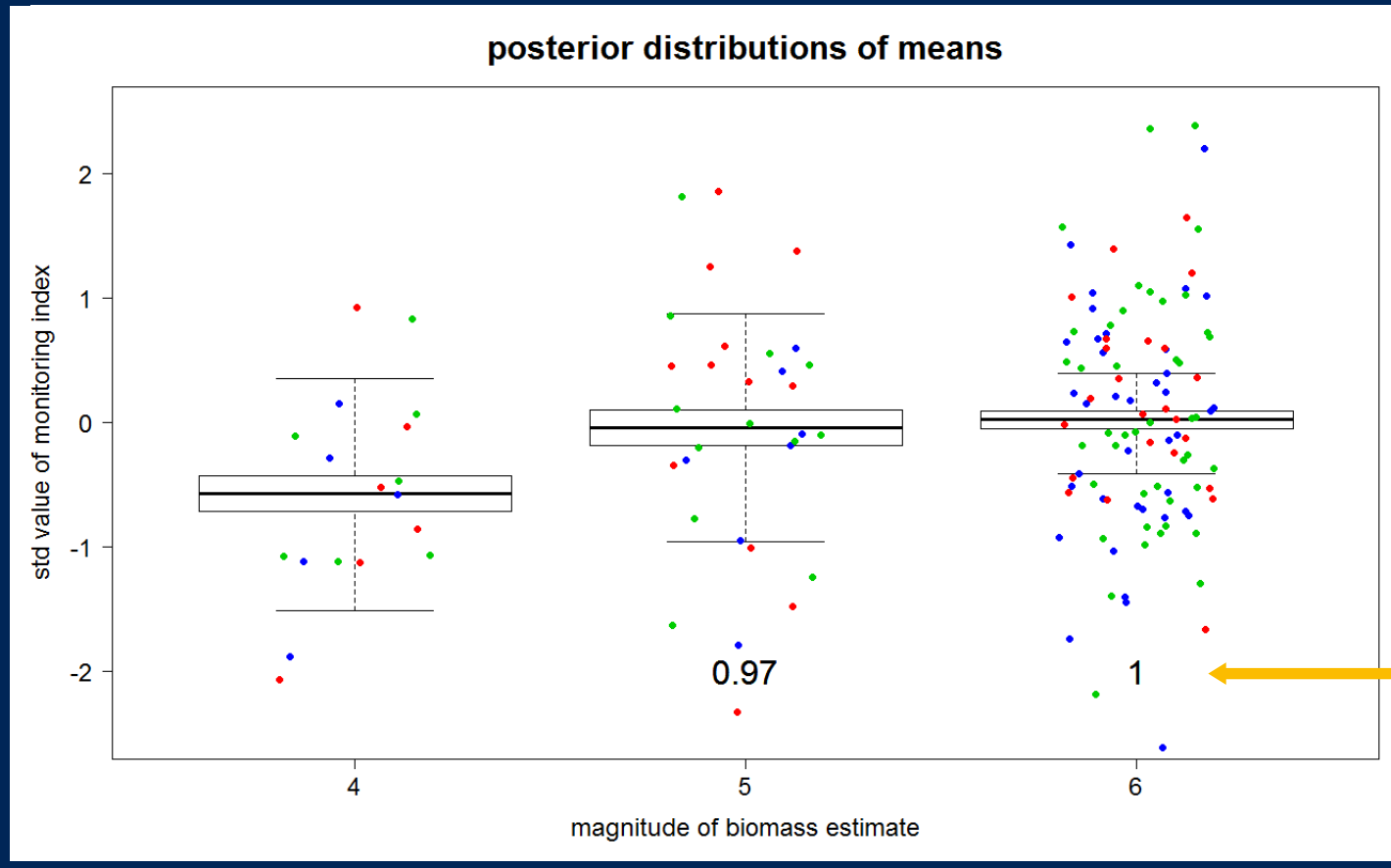
Penguin performance linked to krill biomass





Pr(mean at 4 < mean at *x*)

Penguin performance worse when krill biomass is low

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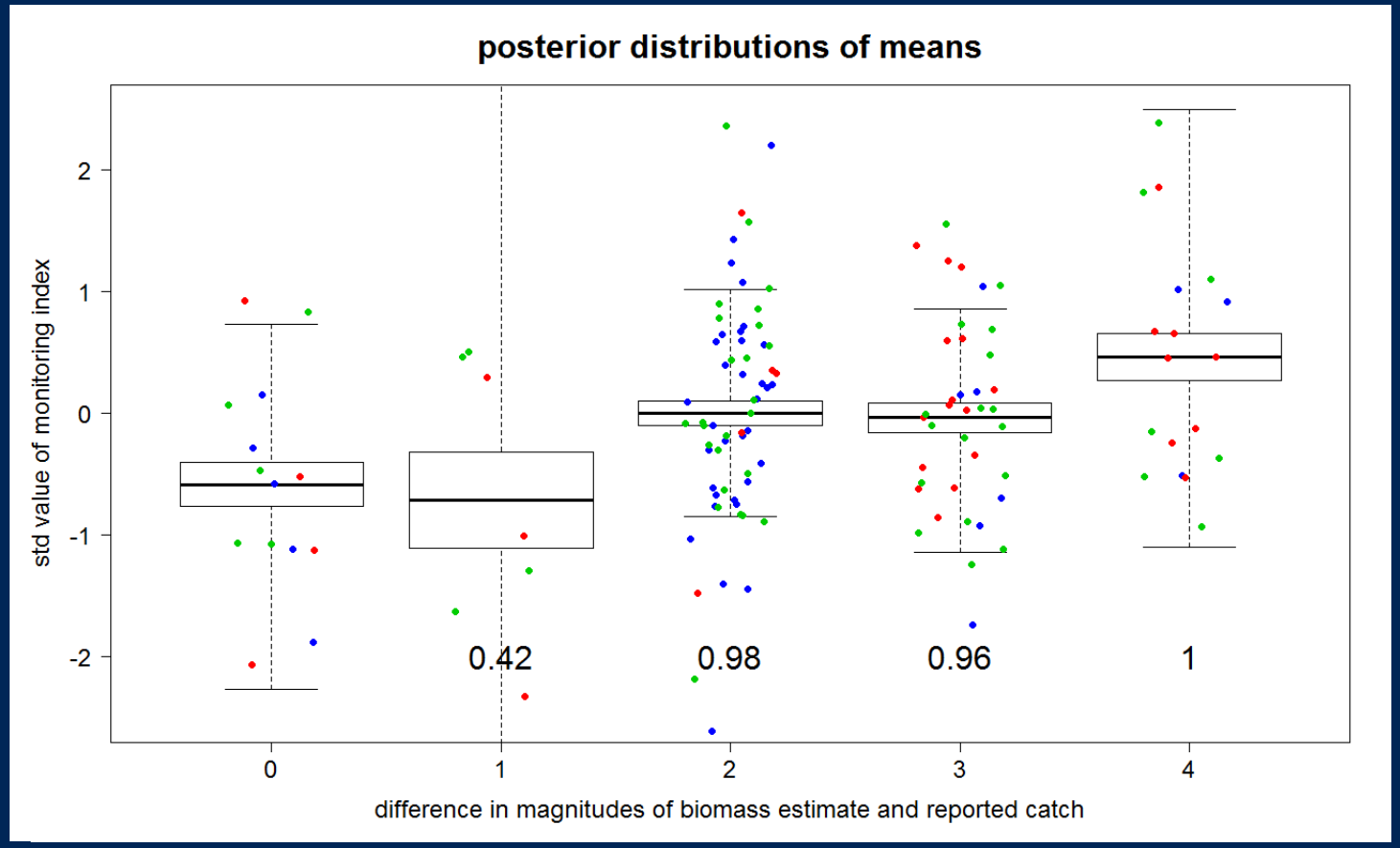
Observed effects of krill fishing



Penguin performance worse when krill catches are high relative to krill biomass.
Local harvest rates matter.

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Answers to TOR questions

4. AERD has worked hard to maintain long-term data sets necessary for advising on ecosystem-based fisheries management. These data are front-and-center in current efforts to establish management strategies for the Antarctic krill fishery and have been used previously to set the template for current fishing management.

5. At present, new ecosystem-based management strategies that use AERD data sets are in development.

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Other approaches to extend reach, fills gaps, and minimize footprint

- Photography and photogrammetry
  - Time-lapse systems
    - Calibration studies
    - CEMP network
    - Winter attendance
  - Unmanned aerial systems
    - Aerial abundance surveys
    - Focal individual mass, condition
  - Animal borne video
    - Foraging specialization
- Mark-recapture studies
- Animal-borne CTD tags for oceanographic observations
- Predator diet and foraging ecology
  - Diets, scats, stable isotopes (bulk and compound-specific), fatty acid analyses, and calorimetry
  - Integrated 3-D tracking, radio telemetry
- Population genetics
  - DNA archives
- Persistent organic pollutants and heavy metals in the food web
- Tooth-ageing to reconstruct demographics
- Otolith records from diet studies

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STRENGTHS

- Long-term data sets
- Consistent standardized methods
- Adaptive to change
  - e.g., Copa field ops
- Collaborations
  - International (Chile, Argentina, Poland, Australia, Ukraine, U.K., Italy, Canada, etc.)
  - National (LSU, UCSC, UNCW, Pomona College, UCSD, etc.)
- 2 field camps dedicated to long-term studies

CHALLENGES

- Integration of data sets (data basing)
- Modernizing observation techniques (instruments, bands, etc.)
- Direct engagement of our data in management decisions
- Maintaining 2 field camps

OPPORTUNTIES

- Moving beyond local indices to regional understanding
- EBFM based on monitoring data
- Informing spatial planning (e.g., MPA development) in the Southern Ocean

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